APPENDIX K
Groundwater Quality Conditions

FLORIDAN AQUIFER SYSTEM

The Floridan Aquifer System (FAS) is made up of the Upper Floridan Aquifer (UFA), a middle confining unit and the Lower Floridan Aquifer (LFA) as shown in **Figure 1**. From a groundwater use perspective the UFA provides most of the freshwater needs of the Kissimmee Basin. The upper portion of the LFA is increasingly used as a source, particularly for public water supply needs in Orange County (O'Reilly *et al*. 2002).

The recharge areas for both the UFA and LFA are in the Lake Wales Ridge Area of Polk County in the southwestern portion of the planning area. Movement of groundwater in the FAS is generally from southwest to northeast (O'Reilly *et al*. 2002). Water quality in the UFA generally meets potable standards in most of the Kissimmee Basin (KB) Planning Area, except for the southeastern portion which becomes more saline. Water quality in the LFA can vary depending on several factors, such as initial chemical composition and solubility of the aquifer material and the presence of connate water from historic marine inundations. Each of these factors contributes to the degree of mineralization of the water. Higher mineralization translates into lower quality.

Figure 2 through **Figure 5** are maps of chloride ion and total dissolved solids (TDS) concentrations within the UFA and the LFA compiled from data obtained over a 15-year period. **Table 1** and **Table 2** list the locations and depths of the wells used to create the figures.

The FAS groundwater is least mineralized in recharge areas along the western part of the basin. Along parts of the Wekiva and St. Johns Rivers, and in much of northeastern and southeastern parts of the Kissimmee Basin, the FAS groundwater is very mineralized (O'Reilly *et al*. 2002). The areas of increased mineralization could be a result of the factors previously mentioned or could be due to saline upwelling.

The lowest chloride concentrations occur in central and western parts of the basin for both the UFA and LFA (**Figure 2** and **Figure 3**). The highest chloride concentrations appear in wells found in the northeast and southeast of the basin. Chloride concentrations are known to exceed 1000 mg/L along St. Johns River and portions of eastern Orange County (O'Reilly *et al*. 2002). A comparison of current chloride concentrations in the UFA to those found in the 1960s shows only minor changes for most of the Orange County area; however, concentrations appear to have increased in the southeast near the Cocoa wellfield, most likely due to upwelling of deeper saline water in response to wellfield pumping (Adamski 2003). Chloride data in proximal wells or even in the same well can vary over time for many reasons. Lowered aquifer heads may cause upcoming or lateral intrusion of more saline water.

Total dissolved solid concentrations also tend to be within drinking water standards (500 mg/L) in the UFA in all except for the extreme southeast portion of the planning area. **Figure 3** shows the distribution of TDS concentrations in the UFA within the planning area.

Figure 4 and **Figure 5** show spatial chlorides and TDS concentrations in the LFA. These contours are based on a very limited amount of data. **Figure 5** shows that TDS in the LFA exceeds the drinking water standard of 500 mg/L for most of the KB Planning Area except in the extreme northwest Lake County and central Highlands County. This may simply be an artifact of the lack of even spatial coverage of LFA well data currently available.

Recent U.S. Geological Survey (USGS) studies categorize the groundwater quality types occurring in the Kissimmee Basin. In most of Orange County, groundwater in the UFA and LFA is of a calcium or calcium-magnesium bicarbonate type. Water from wells near Cocoa wellfield in southeast Orange County is of a sodium-chloride type (Adamski 2003). In northwest Osceola County, sodium-chloride water occurs where chloride concentrations exceed 250 mg/L (Schiner 1993).

A study including all of Orange County and parts of Osceola and eastern Polk counties found three main types of groundwater in the LFA (O'Reilly *et al*. 2002).

1. The inland areas have water enriched in calcium, magnesium and bicarbonate ions.

2. A second type of LFA water is enriched in calcium, magnesium and sulfate, probably due to dissolution of gypsum in deep parts of the aquifer.

3. Sodium-chloride type water occurs in the eastern parts of the basin due to mixing of relict seawater, or upwelling of deep saline water.

Figure 6 illustrates the sodium-chloride type water east of the planning area containing chloride concentrations greater that 250 mg/L. The estimated position of the 250 mg/L isochlor is less than 200 feet below sea level in much of the eastern part of the basin. The 250 mg/L isochlor increases with depth towards the west. The water quality within the center of the KB Planning Area shows that chloride concentrations are lower than 250 mg/L for the upper portion of the LFA. The altitude of the 250 mg/L isochlor exceeds 2,000 feet below sea level in the southwest part of the basin. LFA water in the southwestern part of the basin is not considered fresh (below 250 mg/L), even though chloride concentrations are low. Limited data suggests the water may be of a calcium-sulfate type and mineralized due to high concentrations of sulfate (O'Reilly 2002).

SURFICIAL AQUIFER SYSTEM

The Surficial Aquifer System (SAS) is predominantly unconsolidated quartz sand with varying amounts of shell, limestone and clay from the late Miocene to Holocene age (**Figure 1**). The SAS is an unconfined aquifer with the upper boundary being defined by the water table. The thickness of the SAS varies from 30 feet to 225 feet in the KB Planning Area.

Water quality in the SAS is highly variable depending on aquifer materials, interaction with the UFA and effects of land use. In general, water quality is good (non-mineralized) due to direct recharge by precipitation. However, varying water types, such as calcium-bicarbonate, calcium sulfate and sodium chloride occur within the Kissimmee Basin and are a good indicator of the geochemical evolution and nature of the origin of these waters. The most common water quality problem with the SAS is high concentrations of iron that cause staining.

In the northern part of the basin, mainly Orange and Osceola counties, the water type is calcium bicarbonate and tends to vary, moving toward the lower parts of the basin. Water quality in the SAS generally meets State of Florida secondary drinking water standards, except for iron concentrations. Chloride and sulfate concentrations are significantly less than the 250 mg/L limit (State of Florida secondary drinking water standard) at most locations. As previously noted, brackish water from the FAS introduced into the SAS by irrigation, upward leakance and leaking well casings could locally result in chloride and sulfate concentrations greater than the 250 mg/L standard.

A general water quality assessment was performed on a selected set of data points that were collected from the SFWMD database and from USGS publications. The data represents the period of 1998 to 2003. These data are provided in **Table 3**.

The SAS along the Kissimmee River valley and adjacent parts of the Lake Wales Ridge are shown to have lower alkalinities than in the rest of the Kissimmee Basin. The alkalinity increases when moving toward the Atlantic coast. Concentrations of chlorides and TDS were generally low in SAS wells. **Figure 7** and **Figure 8** show the chlorides and TDS concentrations distributed within the KB Planning Area. Again, these concentrations can vary significantly due to local conditions, but concentrations tend to be higher in areas along the rivers and most likely represent upwelling and discharge of deeper waters from the UFA (Adamski and German 2003 unpublished). The average pH in SAS water ranges from 6.0 to 7.0 within most of the Kissimmee Basin, with some lower values found near the lower lying wetland areas. High chloride concentrations in the SAS in the eastern portion of the Kissimmee Basin correspond with locations where the potentiometric surface of the UFA is higher than the land surface. Here, high chloride water from the UFA may leak upward into the SAS (Adamski and German 2003).

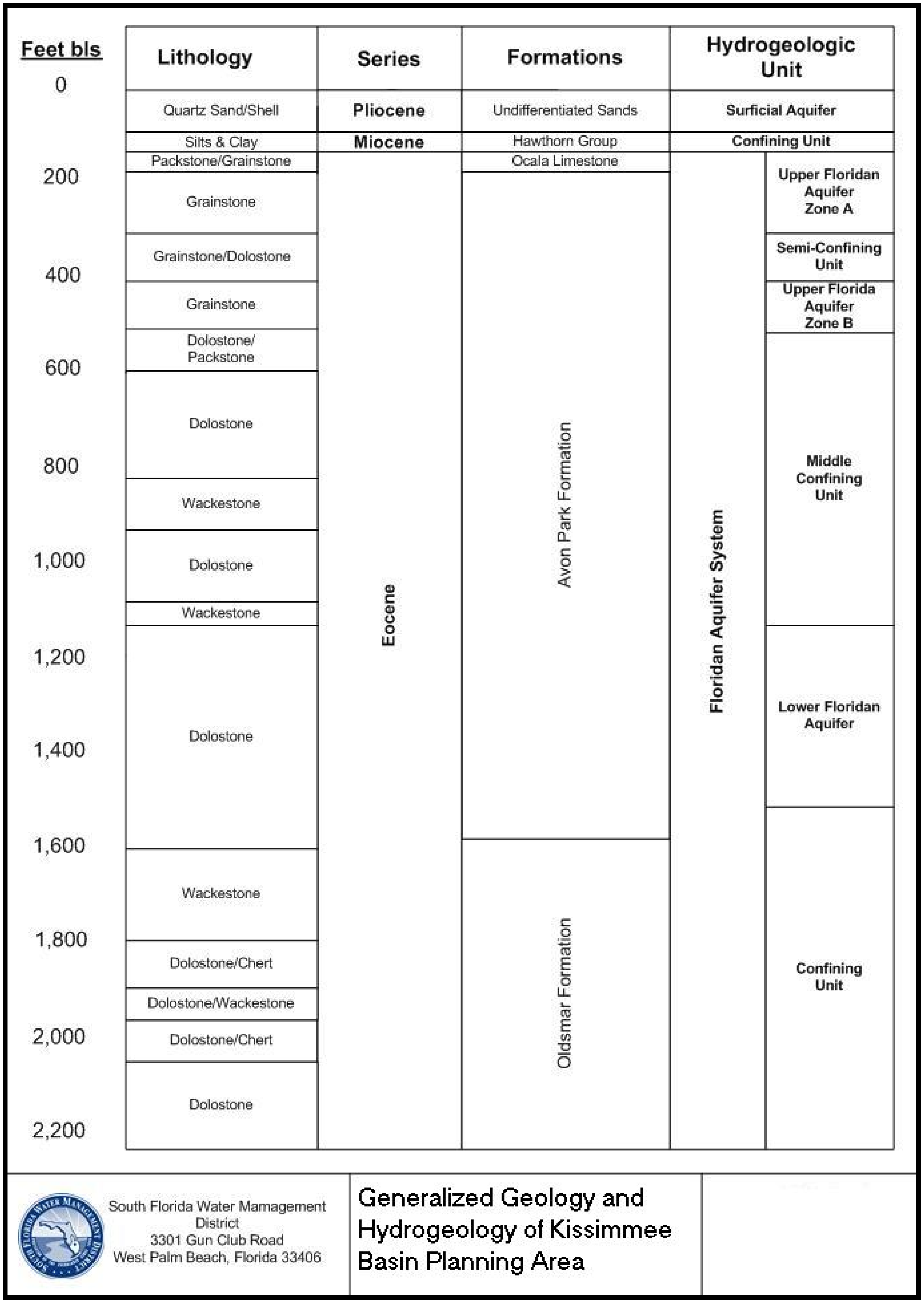

Figure 1. Generalized Geology and Hydrogeology of the Kissimmee Basin Planning Area.

Nutrient concentrations in the sampled SAS wells are low for those wells found in the northern portion of the KB Planning Area (Adamski and German 2003 unpublished). Nutrients can increase in localized areas resulting in contamination from land use. Phosphorus concentrations greater than 1.0 mg/L in monitoring wells around the Orlando area suggest possible heavy use of fertilizers from past and present land use. Concentrations of phosphorus greater than 0.1 mg/L in the SAS can stimulate algal growth in lakes, as groundwater from the SAS discharges into lakes and streams. This is evident in some of the lake water quality data collected throughout the basin.

SUMMARY

Surficial Aquifer

Water quality in the SAS is predominantly calcium-bicarbonate and to some extent sodium-chloride with low mineralization due to direct recharge by precipitation. Water quality data provided in **Table 3** indicates the shallow aquifer water meets potable drinking water standards of the state of Florida, except for iron.

Upper Floridan Aquifer

Water quality in the UFA within the KB Planning Area is generally of potable quality, except for the extreme southern portions of the basin. The chloride and TDS trends show that most of the KB Planning Area is within the 250 mg/L isochlor and 500 mg/L contour for TDS, except for the southeastern corner of the planning area. **Table 1** provides the water quality data from select wells. The water found in the UFA is usually characterized as calcium-bicarbonate, while the southern portion of the basin is characterized as calcium sulfate to the west and sodium chloride to the south. Most of the sodium-chloride groundwater within the UFA is a result of remnant connate water trapped in the aquifer due to prior marine deposition. Within the KB Planning Area, pH ranges from 7.0 to 8.0 in the Floridan Aquifer.

Lower Floridan Aquifer

Water quality in the LFA is influenced by many factors. These factors include the initial chemical composition and solubility of the aquifer material, and the length of time the water remains in contact with that aquifer material and connate water. The most important parameters characterizing water quality in the Lower Floridan Aquifer are chlorides, TDS and sulfates. Water in the LFA generally decreases in quality with increasing depth. The water quality within the LFA can be a function of the marine depositional environment. LFA water in the northern portion of the Kissimmee Basin is defined as the calcium bicarbonate type and is generally of potable quality in upper portions of the aquifer. The quality appears to degrade to sodium chloride in the south and towards the coastlines (east and west). Poor water quality of calcium-sulfate concentration exists within the Kissimmee Basin in areas of Polk and Highlands counties and in some Floridan Aquifer wells that penetrate deep into the lower portion of the aquifer, rich in calcium sulfate evaporates.

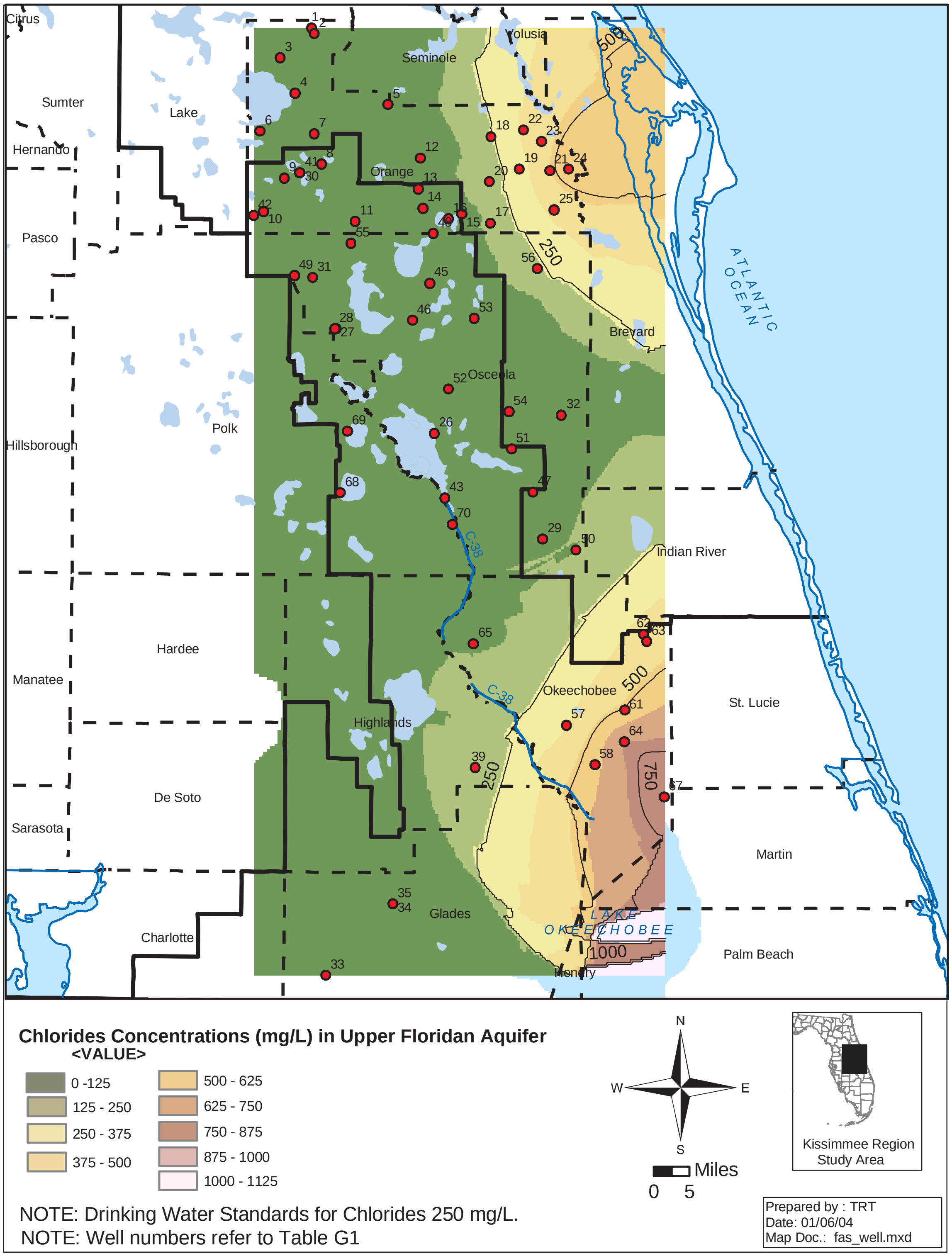

Figure 2. Chloride Concentrations in the Upper Floridan Aquifer.

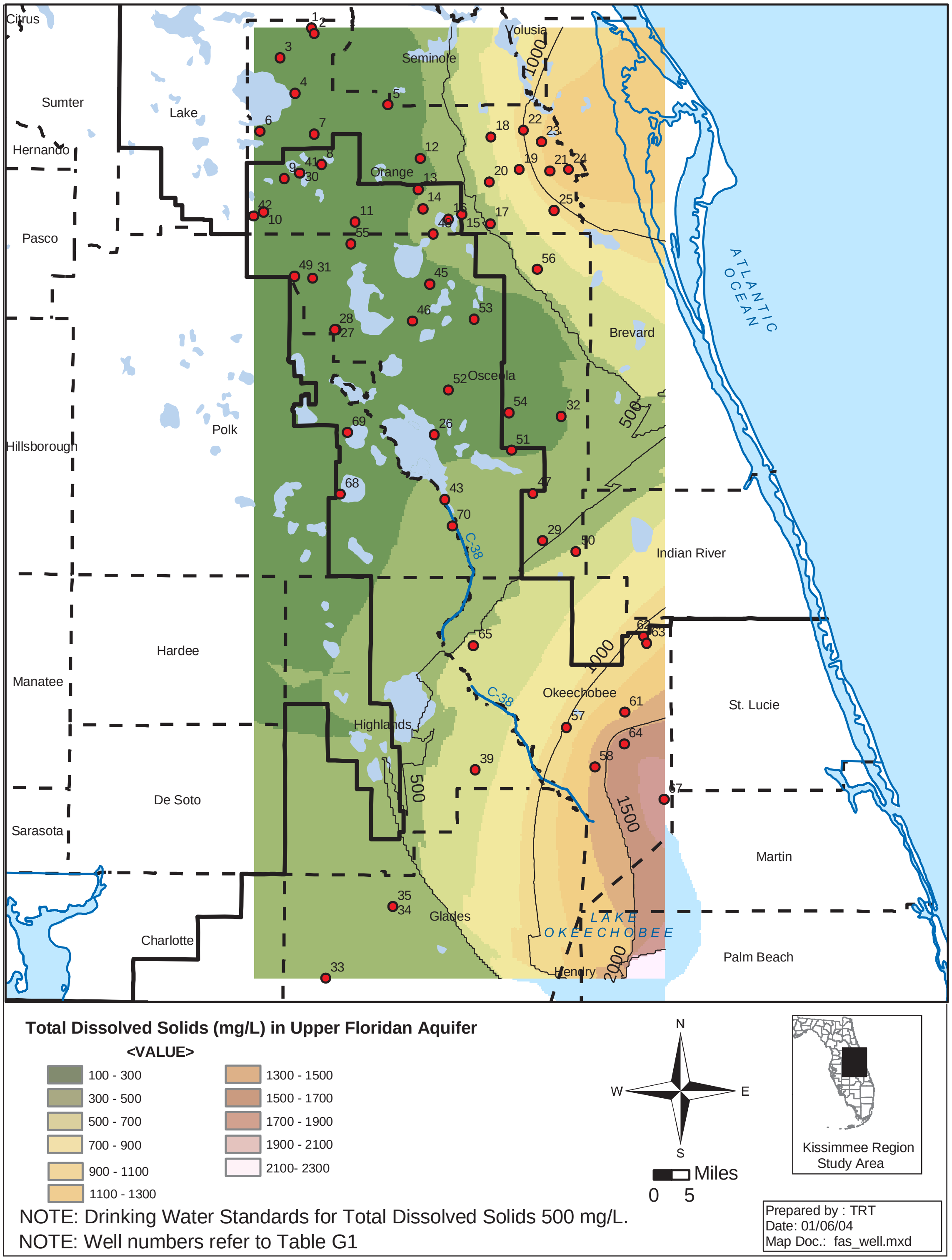

Figure 3. Total Dissolved Solids Concentrations n the Upper Floridan Aquifer.

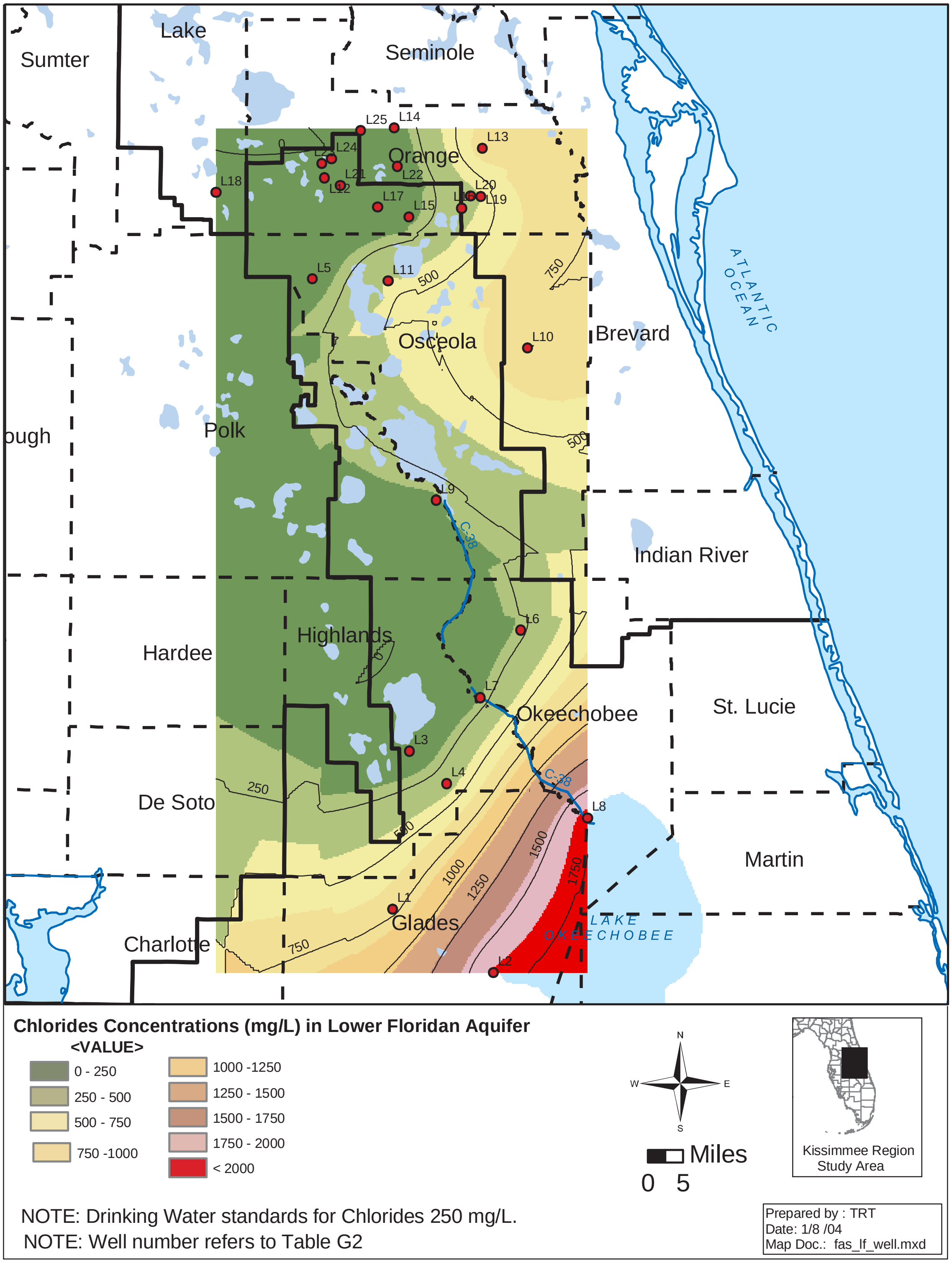

Figure 4. Chloride Concentrations in the Lower Floridan Aquifer.

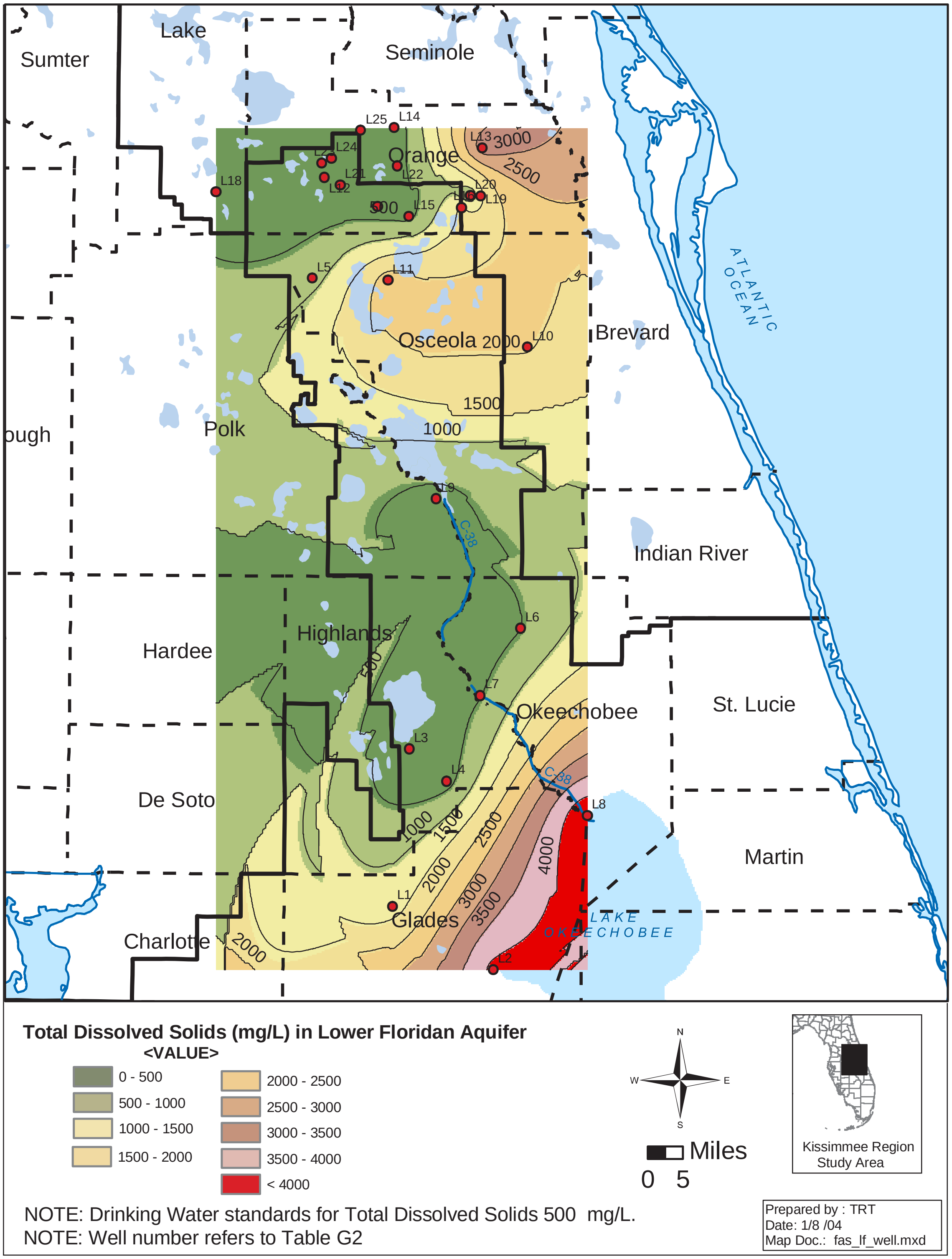

Figure 5. Total Dissolved Solids Concentrations in the Lower Floridan Aquifer.

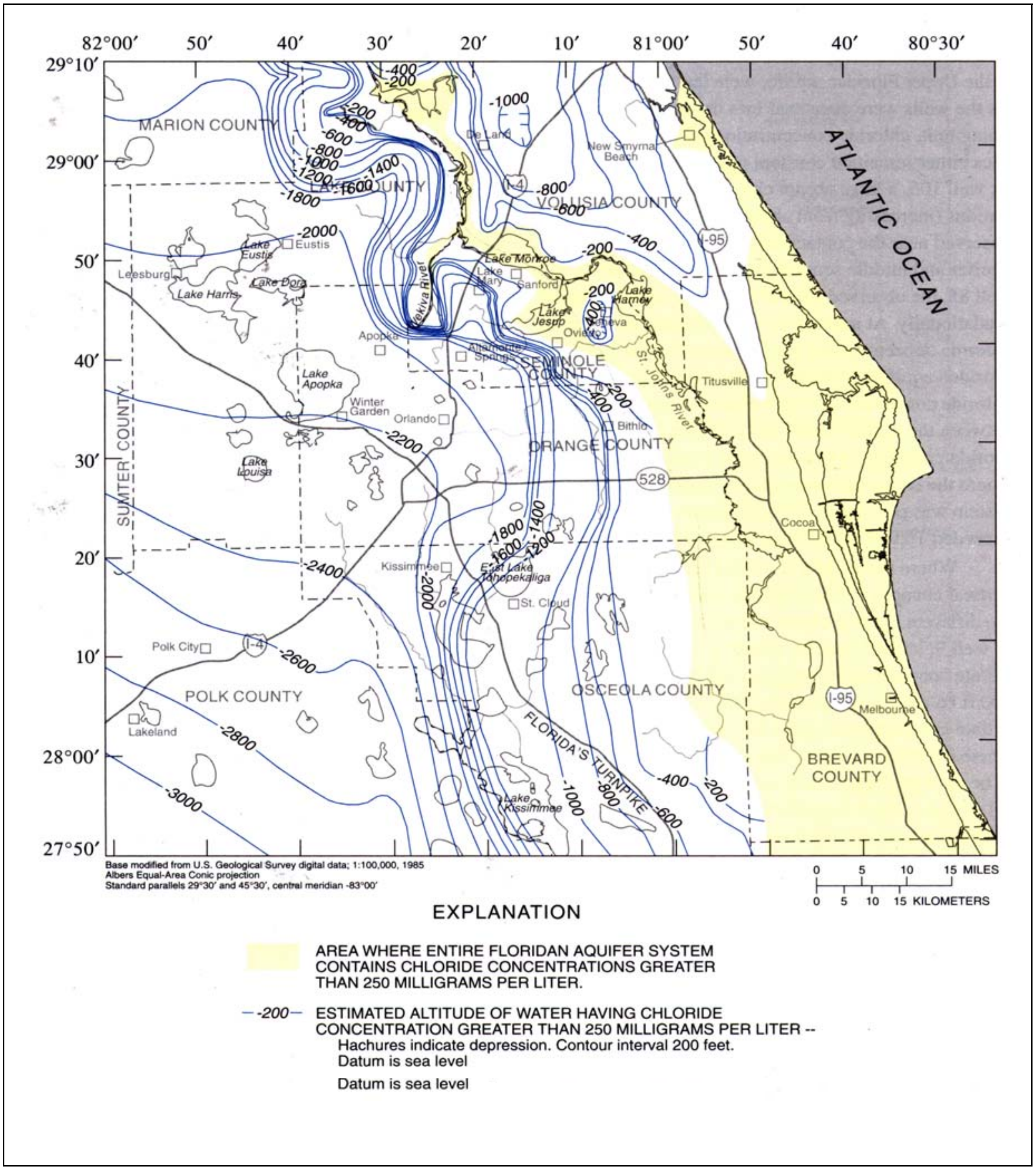

Figure 6. Estimated Altitude of Water in the Floridan Aquifer System Having Chloride Concentrations Greater Than 250 Milligrams Per Liter (McGurk et al. 1998).

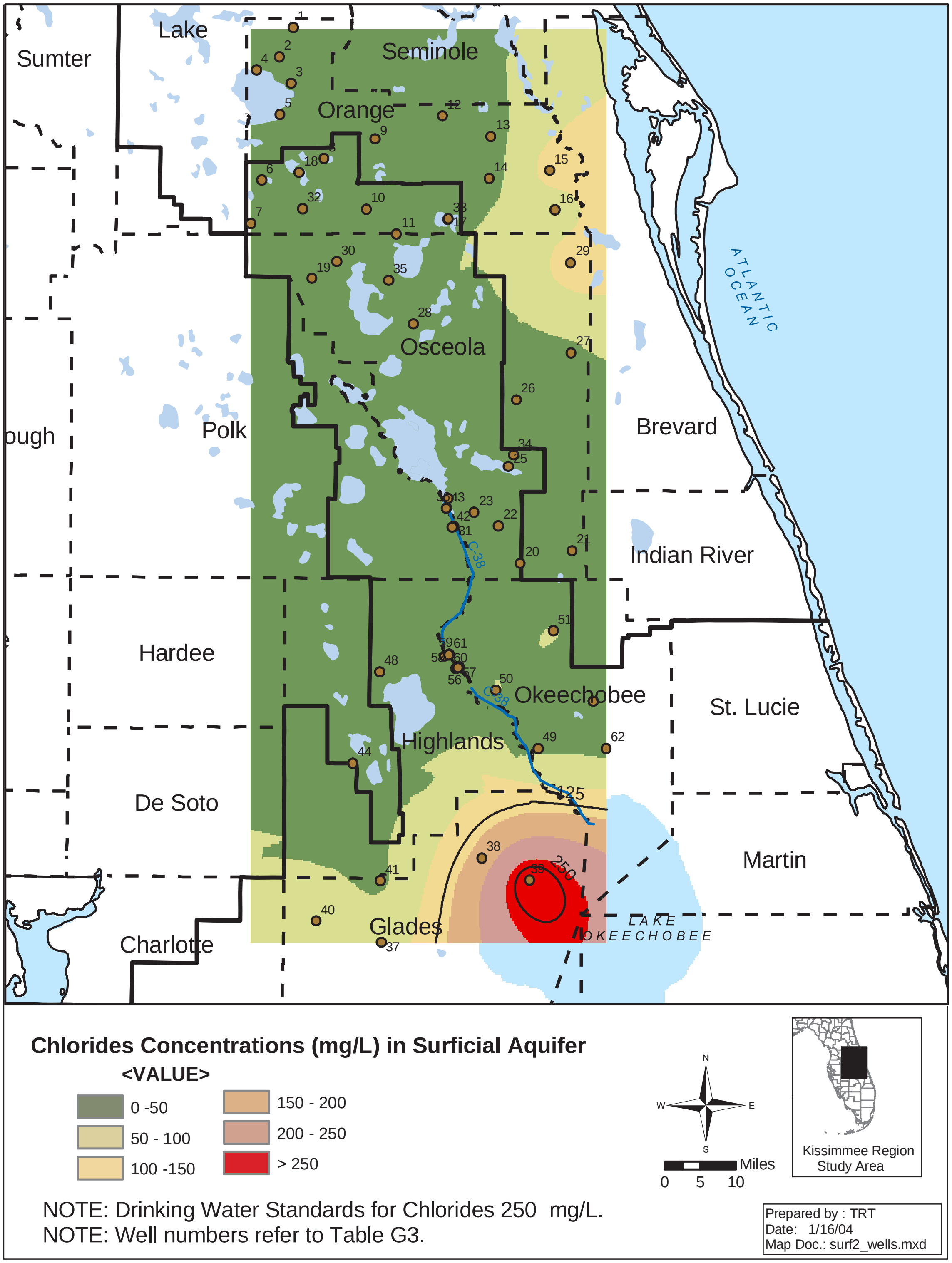

Figure 7. Chloride Concentrations in the Surficial Aquifer.

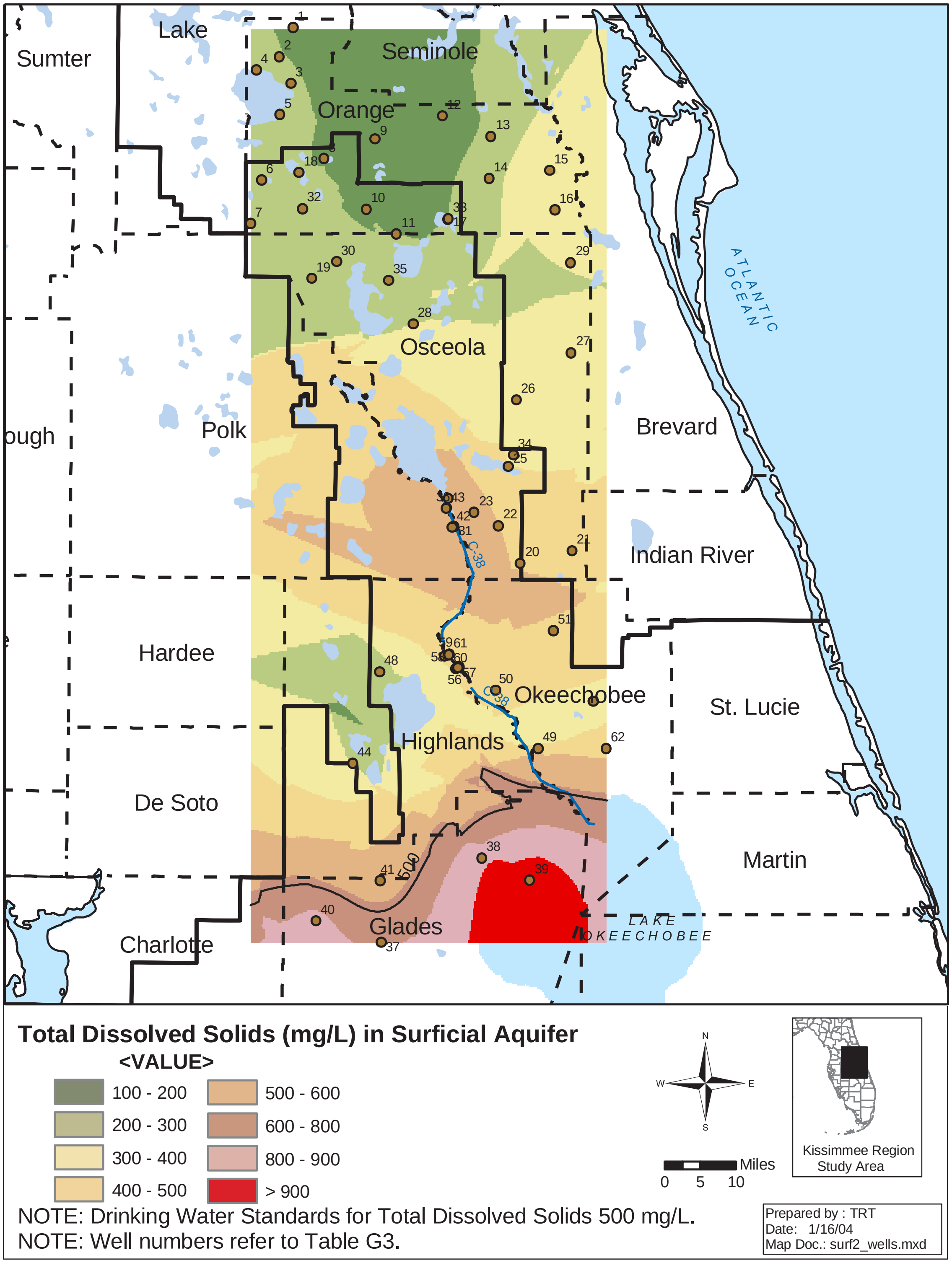

Figure 8. Total Dissolved Solids Concentrations in the Surficial Aquifer.

Table 1. FAS TDS and Chloride Data from Selected Upper Floridan Aquifer Wells.

Site #	Well Name	Total Dissolved Solids (mg/L)	Chlorides (mg/L)	Open Interval or Total Depth	Source	County
1	284612081303401	273.0	7.7		USGS	Orange
2	284529081301001	119.0	7.3	365	USGS	Orange
3	284230081345301	141.0	8.6	--	USGS	Orange
4	283809081324801	196.0	--	--	USGS	Orange
5	283646081195401	146.0	11.0	--	USGS	Orange
6	283325081374001	204.0	16.0	--	USGS	Orange
7	283307081300801	45.0	9.0	--	USGS	Orange
8	282924081290401	168.0	13.0	--	USGS	Orange
9	282738081341401	150.0	5.9	--	USGS	Orange
10	282331081370801	346.0	90.0	--	USGS	Orange
11	282219081242501	255.0	14.0	--	USGS	Orange
12	283011081152301	167.0	11.0	--	USGS	Orange
13	282623081153801	273.0	17.0	248-1004	USGS	Orange
14	282400081150201	471.0	156.0	--	USGS	Orange
15	282315081093601	353.0	34.0	--	USGS	Orange
16	282241081112801	411.0	38.0	--	USGS	Orange
17	282208081053501	500.0	82.0	--	USGS	Orange
18	283249081053201	320.0	56.0	151-492	USGS	Orange
19	282847081013701	495.0	110.0	252-495	USGS	Orange
20	282716081054501	520.0	96.0	506	USGS	Orange
21	282838080572401	1490.0	640.0	--	USGS	Orange
22	283338081010201	1242.0	550.0	--	USGS	Orange
23	283214080583501	1420.0	560.0	200	USGS	Orange
24	282848080544501	2290.0	1100.0	--	USGS	Orange
25	282348080564701	740.0	330.0	245-381	USGS	Orange
26	275609081132001	--	14.0	288-400	USGS	Osceola
27	280905081270101	--	6.0	134-398	USGS	Osceola
28	280905081270102	--	300.0	322-1097	USGS	Osceola
29	274307080582401	--	54.0	218-767	USGS	Osceola
30	ORF-61	153.0	10.4	--	SFWMD	Orange
31	OSF-97	350.0	4.7	--	SFWMD	Osceola
32	275826080554701	500.0	77.0	--	USGS	Osceola
33	RTA-007	504.9	112.3	410	DBHYDRO	Glades
34	GL-5A	310.0	44.5	550	DBHYDRO	Glades
35	GL-5B	285.0	25.4	928	DBHYDRO	Glades
39	HIF-0006	423.1	70.5	520	DBHYDRO	Highlands
41	ORF-61	152.7	10.4	650	DBHYDRO	Orange
42	OR-0004	161.0	6.7	83	DBHYDRO	Orange
43	OSF-0052	836.9	357.8	880	DBHYDRO	Osceola
45	OSF-12	242.0	9.5	400	DBHYDRO	Osceola
46	OSF-18	219.0	31.5	500	DBHYDRO	Osceola

Table 1. FAS TDS and Chloride Data from Selected Upper Floridan Aquifer Wells 1988-2003 (Continued).

Site #	Well Name	Total Dissolved Solids (mg/L)	Chlorides (mg/L)	Open Interval or Total Depth	Source	County
47	OSF-21	436.0	134.2	877	DBHYDRO	Osceola
48	OSF-27	593.0	77.8	470	DBHYDRO	Osceola
49	OSF-5	145.0	4.1	231	DBHYDRO	Osceola
51	OSF-62	321.0	77.9	630	DBHYDRO	Osceola
52	OSF-66	122.0	14.1	670	DBHYDRO	Osceola
53	OSF-68	212.0	10.6	500	DBHYDRO	Osceola
54	OSF-84	193.0	8.7	405	DBHYDRO	Osceola
55	OSF-9	133.0	5.5	1195	DBHYDRO	Osceola
56	OSF-92	286.0	198.3	377	DBHYDRO	Osceola
57	OKF-17	527.0	97.2	986	DBHYDRO	Okeechobee
58	OKF-23	953.0	327.3	925	DBHYDRO	Okeechobee
61	OKF-7	224.0	16.8	963	DBHYDRO	Okeechobee
62	OKF-71	1430.0	575.5	855	DBHYDRO	Okeechobee
63	OKF-72	698.0	305.2	800	DBHYDRO	Okeechobee
64	OKF-74	3950.0	1776.8	725	DBHYDRO	Okeechobee
65	OKF-81	410.0	82.4	782	DBHYDRO	Okeechobee
68	POF-0008	90.9	8.3	199	DBHYDRO	Polk
67	OKF-0003	2284.1	1070.4	433	DBHYDRO	Okeechobee
74	Southwest #3 (P-2)	125.0	8.1	1455	USGS	Orange
69	POF-0015	101.0	5.4	575	DBHYDRO	Polk
70	KREFFD	314.0	4.3	120.16	DBHYDRO	Osceola

Table 2. FAS TDS and Chloride Data from Selected Lower Floridan Aquifer Well 1988-2003.

Site #	Well Name	Total Dissolved Solids (mg/L)	Chlorides (mg/L)	Open Interval or Total Depth	Source	County
L1	GL-5C	1263.0	540.4	1390-1350	DBHYDRO	Glades
L2	GLF-6	4140.6	1938.4	2023	DBHYDRO	Glades
L3	HIF-14_G	174.1	30.1	1500	DBHYDRO	Highlands
L4	HIF-0037	314.9	118.3	1450	DBHYDRO	Highlands
L5	OSF-97	820.7	16.4	2480	DBHYDRO	Osceola
L6	OKF-34	491.0	103.5	1143	DBHYDRO	Okeechobee
L7	OKF-42	472.0	56.5	1152	DBHYDRO	Okeechobee
L8	OKF-100	12910.7	6340.7	2043	DBHYDRO	Okeechobee
L9	POF-21	359.0	87.9	1035	DBHYDRO	Polk
L10	Bull Creek OS-0025	2040.0	930.0	1483-1473	USGS	Osceola
L11	OSF-0081	2280.0	730.0	2210	USGS	Osceola
L12	Southwest #3 (P-2)	125.0	8.1	1455-1003	USGS	Orange
L13	OR-0618	3280.0	1200.0	1280-1140	USGS	Orange
L14	Navy #1	160.0	9.7	1370-1080	USGS	Orange
L15	Southeast #2	360.0	17.0	1441-1045	USGS	Orange
L16	Cocoa	1590.0	370.0	1205-1098	USGS	Orange
L17	Orange Test Well	258.0	15.0	1424-1098	USGS	Orange
L18	Lk Louisa State Pk	210.0	8.3	1410-1295	USGS	Lake
L19	Cocoa (OR-0613)	1460.0	390.0	1500-1428	USGS	Orange
L20	Cocoa C Zone 3	533.0	81.0	1224-1218	USGS	Orange
L21	Sand Lake	185.0	3.0	2030-2005	USGS	Orange
L22	Orange Conway #4	--	9.8	1400-1100	USGS	Orange
L23	Hidden Springs #4	156.0	8.5	1401-1250	USGS	Orange
L24	Kirkman #3	149.0	8.3	1400-943	USGS	Orange
L25	Lake Adair 9	97.0	8.7	1281-601	USGS	Orange

Table 3. SAS TDS and Chloride Data from Selected Surficial Aquifer Wells 1988-2003.

Site #	Well Name	Total Dissolved Solids (mg/L)	Chlorides (mg/L)	Open Interval or Total Depth	Source	County
1	284604081330301	103	17	75	USGS	ORANGE
2	284230081345302	51	5.3	40	USGS	ORANGE
3	283914081331702	185	5		USGS	ORANGE
4	284051081380701	451	23		USGS	ORANGE
5	283524081344701	313	34		USGS	ORANGE
6	282722081371701	224	7.6		USGS	ORANGE
7	282202081384602	138	8.1	38	USGS	ORANGE
8	283003081283801	76	7	54	USGS	ORANGE
9	283228081213501	98	36	25	USGS	ORANGE
10	282352081224401	70	20	29	USGS	ORANGE
11	282051081183402	96	31		USGS	ORANGE
12	283517081121501	26	5.7	15	USGS	ORANGE
13	283249081053203	88	12	15	USGS	ORANGE
14	282739081054502	316	12	30	USGS	ORANGE
15	282838080572402	629	180	17	USGS	ORANGE
16	282348080564301	277	9.2	30	USGS	ORANGE
17	282241081112802	105	38	29	USGS	ORANGE
18	ORS-3	180	9.9	32-52	SFWMD	ORANGE
19	IC_SAS	300	14.1	15-20	SFWMD	OSCEOLA
20	274032081012701		2.4	9	USGS	OSCEOLA
21	274204080542901		9.8	100	USGS	OSCEOLA
22	274509081042901		30	7	USGS	OSCEOLA
23	274646081074801		15	23	USGS	OSCEOLA
24	274827081112302		57	N/A	USGS	OSCEOLA
25	275222081030702		29	28	USGS	OSCEOLA
26	280033081015802		7.1	130	USGS	OSCEOLA
27	280619080542602		20	16	USGS	OSCEOLA
28	280950081161501		13	65	USGS	OSCEOLA
29	281722080543001		170	19	USGS	OSCEOLA
30	281724081265301		29	8	USGS	OSCEOLA
31	KRENNM1	446	8.3	37	SFWMD	OSCEOLA
32	OR-0003	352	60.3	18	DBHYDRO	ORANGE
33	OR-0010	123.1	46.2	29	DBHYDRO	ORANGE
34	WELL#41S	30	11.6	28.04	DBHYDRO	OSCEOLA
35	WELL#45S	400	23	26.52	DBHYDRO	OSCEOLA
36	KRFNNS	500	3.5	21.26	DBHYDRO	OSCEOLA
37	GLWQ-01	378.1	28.7	54	DBHYDRO	GLADES
38	GLWQ-04	825	152.4	75	DBHYDRO	GLADES
39	GLWQ-06	1145	370.1	46	DBHYDRO	GLADES
40	GLWQ-08	992.9	120.4	85	DBHYDRO	GLADES
41	GLWQ-09	89.9	11.2	33	DBHYDRO	GLADES

Table 3. SAS TDS and Chloride Data from Selected Surficial Aquifer Wells 1988-2003 (Continued).

Site #	Well Name	Total Dissolved Solids (mg/L)	Chlorides (mg/L)	Open Interval or Total Depth	Source	County
42	KREFFS	400	3.4	20.51	DBHYDRO	POLK
43	KRFFFS	860	18	21.4	DBHYDRO	POLK
44	HI-0440A	71	7.2	23	DBHYDRO	HIGHLANDS
46	KRBNNS	360	18	30	DBHYDRO	HIGHLANDS
47	KRDNNS1	450	24	25	DBHYDRO	HIGHLANDS
48	MR-0158	59.1	4.5	10	DBHYDRO	HIGHLANDS
49	OKS-83S1	103	12.1	20	DBHYDRO	OKEECHOBEE
50	OKS-84	482	64.3	178	DBHYDRO	OKEECHOBEE
51	OKS-96M1	480	70	50.8	DBHYDRO	OKEECHOBEE
52	OKS90DP1	327	10.8	93.1	DBHYDRO	OKEECHOBEE
53	OKS90S01	118	18.8	20.5	DBHYDRO	OKEECHOBEE
54	KRAFFM	330	36	40.37	DBHYDRO	OKEECHOBEE
55	KRAFFS	1500	25	23.45	DBHYDRO	OKEECHOBEE
56	KRANNM	350	53	48.52	DBHYDRO	OKEECHOBEE
57	KRANNS	740	15	24.2	DBHYDRO	OKEECHOBEE
58	KRCFFM	370	28	41.77	DBHYDRO	OKEECHOBEE
59	KRCFFS	450	33	24.81	DBHYDRO	OKEECHOBEE
60	KRCNNM	330	35	42.62	DBHYDRO	OKEECHOBEE
61	KRCNNS	420	33	20	DBHYDRO	OKEECHOBEE
62	GRW1	223	13.7	17	DBHYDRO	OKEECHOBEE

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